CLAIMS

1. A method of manufacturing a semiconductor device, comprising an etching step of opening a contact hole in an insulating film by reactive ion etching;

wherein said etching step includes a first step of carrying out etching at a predetermined etching rate and a second step of carrying out etching at a rate lower than said predetermined etching rate; and

wherein said second step is carried out after said first step is carried out and before an underlayer is exposed by the opening, and a gas with a composition and a supply amount is supplied in said second step, at least one of said composition and said supply amount of said gas being different from a composition and a supply amount of a gas supplied in said first step.

2. A semiconductor device manufacturing method according to claim 1, wherein:

said contact hole is formed in the insulating film on at least one of a source region and a drain region of a field-effect transistor.

3. A semiconductor device manufacturing method according to claim 1 or 2, wherein:

said insulating film is a silicon oxide film.

4. A semiconductor device manufacturing method according to any of claims 1 to 3, wherein:

said supply gas contains at least C and F and the supply amount of said supply gas is reduced in said second step as compared with that in said first step.

5. A method of manufacturing a semiconductor device according to any of claims 1 to 3, wherein:

said supply gas contains oxygen and a gas containing C and F, and a supply amount of said oxygen is reduced in said second step as compared with

that in said first step.

6. A method of manufacturing a semiconductor device according to any of claims 1 to 3 and 5, wherein:

said supply gas contains oxygen and a gas containing C and F, and a supply amount of said gas containing C and F is reduced in said second step as compared with that in said first step.

7. A method of manufacturing a semiconductor device according to any of claims 1 to 3, wherein:

said supply gas contains oxygen and a gas containing C and F, and a composition of said oxygen and said gas containing C and F is changed in said second step from that in said first step.

8. A method of manufacturing a semiconductor device according to any of claims 1 to 7, wherein:

the etching is carried out until80% to 95% of a predetermined depth of said opening in said first step and thereafter said second step is carried out.

9. A method of manufacturing a semiconductor device according to any of claims 1 to 8, wherein:

said reactive ion etching is carried out in a microwave-excited plasma processing apparatus and a power for plasma excitation is reduced in said second step as compared with that in said first step.

10. A method of manufacturing a semiconductor device according to any of claims 1 to 9, wherein:

the composition and supply amount of the gas supplied in said second step are selected so that a thickness of a deposit on a side wall of said opening becomes 10% or less of a diameter of said opening.

11. A method of manufacturing a semiconductor device according to any of claims 1 to 9, wherein:

the composition and supply amount of the gas supplied in said second

step are selected so that a protective film is formed on a surface of the underlayer in said opening.

12. A method of manufacturing a semiconductor device according to claim 10, wherein:

said protective film formed on the surface of the underlayer comprises a fluorocarbon film.

13. A method of manufacturing a semiconductor device comprising a step of carrying out etching by the use of a gas;

wherein at least one of a composition and a flow rate of said gas is changed during said etching and the etching is ended in a state where a surface of an underlayer is protected.

14. A method of manufacturing a semiconductor device according to claim 13, wherein:

the etching by the gas of which said at least one of the composition and flow rate is changed can prevent inactivation of boron on the surface of said underlayer.

15. A method of manufacturing a semiconductor device according to claim 13 or 14, wherein:

said gas contains at least C and F.

16. A method of etching an insulating film for forming an opening in the insulating film by reactive ion etching, wherein:

said etching includes a first step of carrying out etching at a predetermined rate and a second step of carrying out etching at a rate slower than said rate, and said second step is carried out after said first step is carried out and before an underlayer is exposed by said opening ; and

wherein a gas with a composition and a supply amount is supplied in said second step, at least one of said composition and said supply amount being different from a composition and a supply amount of a gas supplied in

said first step.

17. A method of etching an insulating film according to claim 16, wherein:

said insulating film is a silicon oxide film.

18. A method of etching an insulating film according to claim 16 or 17, wherein:

said supply gas contains at least C and F and the supply amount of said supply gas is reduced in said second step as compared with that in said first step.

19. A method of etching an insulating film according to any of claims 16 to 18, wherein:

said supply gas contains oxygen and gas containing C and F, and a supply amount of said oxygen is reduced in said second step as compared with that in said first step.

20. A method of etching an insulating film according to any of claims 16, 17, and 19, wherein:

said supply gas contains oxygen and gas containing C and F, and a supply amount of said gas containing C and F is reduced in said second step as compared with that in said first step.

21. A method of etching an insulating film according to any of claims 16 to 20, wherein:

said supply gas contains oxygen and gas containing C and F, and a composition of said oxygen and said gas containing C and F is changed in said second step from that in said first step.

22. A method of etching an insulating film according to any of claims 16 to 21, wherein:

the etching is carried out till 80% to 95% of a predetermined depth of said opening in said first step and thereafter said second step is carried out.

23. A method of etching an insulating film according to any of claims 16 to 22, wherein:

said reactive ion etching is carried out in a microwave-excited plasma processing apparatus and a power for plasma excitation is reduced in said second step as compared with that in said first step.

24. A method of etching an insulating film according to any of claims 16 to 23, wherein:

the composition and supply amount of the gas supplied in said second step are selected so that a thickness of a deposit on a side wall of said opening becomes 10% or less of a diameter of said opening.

25. A method of etching an insulating film according to any of claims 16 to 23, wherein:

the composition and supply amount of the gas supplied in said second step are selected so that a protective film is formed on a surface of the underlayer in said opening.